constantly together, rarely being seen twenty feet apart. He is as gallant in the defence of his mate as ever. But the other day I picked up the female to examine more closely the red portion of the head when a vigorous thrust of his sharp beak as he flew at me admonished me that he thought I was taking unwarrantable liberties, and the attack was followed up with great vigor till I got the whip and tickled him smartly about the head, when he retreated in tolerable order. In the mean time the female had got quite a way off, which no doubt he thought a good excuse for the discontinuance of the attack.

A word about the color of these birds. One of the females when they came into my grounds had two white feathers on the back, which have proved constant ever since. All the others are of the regulation blue of the species. I think Audubon would have admitted that a ten year old bird was no longer young, and would have despaired of ever seeing it turn into a white *Grus canadensis.*

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ON THE MICROSCOPIC CRYSTALS CONTAINED IN PLANTS.

BY W. K. HIGLEY.

[*Concluded from October number.*]

I shall now take up the species of the family Vitaceæ and in these a wider view of crystals will be presented.

This family gives us a good field for the examination of both raphides and sphæraphides in the same plants. In all the species that I have examined the raphides were the most abundant in the leaves with their appendages, the petiole, and the epidermis of the stem in young plants, while the sphæraphides were more common in the old stems and berry, but were also found, though rarely, in the other parts mentioned for raphides. Crystals in the grape have been known for a long time. In the common cultivated grape, raphides are abundant, but the largest are only found in the leaf and petiole, and at times much smaller ones may be looked after in the fruit. These crystals, whenever found, gave the test for phosphoric acid and lime. In the pulp of the berry sphæraphides are abundant; those of the fruit stalks were about

$\frac{1}{1000}$th of an inch in diameter. When a collection of these is met with they form a beautiful field, which I think is only surpassed in beauty by the sphæraphid tissue in the testa of the elm. These crystals would not answer to any of the chemical tests except those for calcium, so that I have reason to believe that the base was combined with some organic acid, perhaps tartaric.

Vitis æstivalis and *V. cordifolia* abounded in both sorts of crystals, but neither were as large as in the common grape. In *Ampelopsis quinquefolia* I found raphides, but they were often free, that is they were not in a close bundle. The sphæraphid tissue is very fine in this species. Each crystal seems to form a nucleus to a single cell. The cells are placed very regularly and symmetrical in form. The blackberries contained raphides in more abundance and of a larger form than those of the grape fruits, but the largest were in the leaves and petioles of the younger shoots. The sphæraphides were not as large as those of the grape. As in the genus Vitis the crystals of this species, except those mentioned last, seemed to contain lime as a base and phosphoric acid.

In this family all the crystals contained in the fruit, except the raphides, gave the tests for lime, but failed to give the tests for the common acids, so that I think it probable that the base was in combination with some organic acid. I expected to find in this family more acicular crystals, but in this I was disappointed.

The next order that I shall report upon, as is well known, is the largest natural order, and is represented by a number of hundred species, it being universal. This family, the Compositæ, is well represented in the Northern States. Raphides are not as common in this family as in the other two, Araceæ and Vitaceæ, but forms of all three classes do occur. I have only found the needle-shaped crystals in the ovary or fruit, and sometimes in the receptacle and involucre. In some species minute cubical crystals occur which dissolve with effervescence in acetic acid. Globular masses of crystals known as inuline are quite common. I did not find the raphides in bundles except in one case, *Achillea millifolium*, which contained in the receptacle, on the average, about twenty raphides in each bundle; in all other cases when raphides were found they were single, which was perhaps due to some disturbance.

In *Inula helenium* I could find no crystals except the globular

aggregate known as inuline. This substance is an organic compound having the composition $C_6 H_{10} O_5$. Miller says that this is a variety of starch, insoluble in alcohol but soluble in hot water, and by boiling with dilute acids it is converted first into dextrine and then into pure lævulose. It forms an insoluble precipitate when its solution is mixed with one of acetate of lead and ammonia is added. I did not attempt to extract it from the root as that is quite a difficult operation to perform. The crystals appear like a globular mass with fissures radiating from the center outwards; iodine when applied to the well-cleaned section, gives with inuline a distinct yellow color. This statement is in direct opposition to that made by Fluckiger and Hanbury (see Pharmacographia under elecampane). The only part of the plant that I had was the root, it being too early for the stem, leaves, etc., so that I am not able to state what might be found in the other parts.

Taraxacum dens-leonis also contains inuline, but in much smaller amount than the last, and also a few sphæraphides, which seem to have no particular location, as they may be found, on close examination, in almost any part of the plant, although rare. They were too small and too few in number to obtain any definite chemical tests with them. Also raphides were present, but only in small numbers and not in bundles.

Cichorum intybus contains inuline but it is in still smaller amounts than in the last.

I also found inuline in the root of *Cirsum arvense*, or Canada thistle; in which plant raphides are formed in the flower receptacle and also in the parts of the flower, also some other crystals which seemed to have four faces tapering to a point at each end (crystal prisms). The number of faces were probably double this. These crystals were soluble, with effervescence in hydrochloric and not in acetic acid. The raphides gave the chemical test for phosphate.

In *Cirsium muticum*, or swamp thistle, the crystals of inuline were very small and indistinct. The raphides were found the same as in the last species, though more numerous. The crystal prisms I was not able to find at all, the reason perhaps is, that I had only a young plant, while of the Canada thistle I had a fall or late specimen. *Cirsium lanceolatum* gave the same results as *C. arvense*.

In *Cynthia virginica* raphides of small size but no inuline were found. There were also a few cubical crystals in the lower part of the stem and in the flower receptacle, which gave answer to the test for carbonic acid with acetic acid, but the raphides proved to be phosphate. The cubical crystals were about the $\frac{1}{2000}$th of an inch in diameter.

Senecio aureus and *S. balsamitæ*[1] contained acicular crystals which, upon chemical examination, gave evidence of oxalate of lime. In this genus I was not able to find any raphides at all, nor any inuline. A few crystals were present, but on account of their small size and number, I was neither able to determine their form nor chemical nature.

Lappa major, or common burdock, contained in the flower receptacle and dried fruit, minute cubical crystals, which gave the tests for carbonate of lime. No raphides or acicular crystals of any sort were present.

Tanacetum vulgare contained both cubical and acicular crystals, the latter in the leaves and petiole, and the former in the flower parts; and upper part of the stem; both oxalate and carbonate of lime seemed to be present.

The raphides of this order seem to be rarer in the division or sub-order Ligulifloræ, while the acicular crystals or crystal prisms were only found in the sub-order Tubulifloræ. Inuline is common to both sub-orders.

It will be seen on reference to my work that the raphides seemed to be composed of phosphate of lime, the acicular or crystal prisms, of oxalate, and the cubical crystals, of carbonate of the same, while the sphæraphides seemed to be the same base combined with different acids according to their locality.

It will be remembered that in the first part of this paper I mentioned the fact that crystals of some form were nearly if not quite universal, and as some slight evidence of this I have compiled with care a list of all the families in which crystals have been reported. This is the beginning of a more complete list of the genera and species which I hope soon to have ready for publication, which will be classified according to the kind of crystals that the species may contain.

[1] A variety of *S. aureus*.

The following is the list of families:

CRYPTOGAMIA.

[1] Filices
Equisetaceæ
Hepaticæ
Characeæ
Musci
Algæ
Fungi.

PHÆNOGAMIA.

EXOGENÆ.

Araliaceæ
Aurantiaceæ
Balsaminaceæ
Berberidaceæ
Cactaceæ
Camelliaceæ
Caprifoliaceæ
Caryophyllaceæ
Chenopodiaceæ
Cinchonaceæ
Compositæ
Coniferæ
Crassulaceæ
Cruciferæ
Cycadaceæ
Droseraceæ
Elæagnaceæ
Euphorbiaceæ
Ficoideæ
Fumariaceæ
Galacineæ
Geraniaceæ
Galiaceæ
Haloragеæ
Juglandaceæ
Leguminoseæ
Linaceæ
Melastomaceæ
Nyctaginaceæ
Oleaceæ
Onagraceæ
Orobanchaceæ
Oxalidaceæ
Passifloraceæ
Phytolaccaceæ
Polygonaceæ
Pittosporaceæ
Rubiaceæ
Saxifragaceæ
Scrophulariaceæ (Gelsemineæ)
Tetragonieæ
Tiliaceæ
Urticaceæ
Valerianaceæ
Vitaceæ
Zygophyllaceæ.

ENDOGENÆ.

Amaryllidaceæ
Araceæ
Bromeliaceæ
Burmanniaceæ
Butomaceæ
Cyperaceæ
Dioscoreaceæ
[2] *Gramineæ*
Hæmodoraceæ
Hypoxidaceæ
Iridaceæ
Juncaceæ
Liliaceæ
Linaceæ
Marantaceæ
Melanthaceæ
Musaceæ
Orchidaceæ
Orontiaceæ
Pandanaceæ
Pontederiaceæ
Smilacaceæ
Typhaceæ
Xyridaceæ
Zingiberaceæ.

[1] In this family I have seen crystals but once, and these were contained in *Phegopteris hexagonoptera.*

[2] The crystals of this family were shown to me by a fellow student in the University, Ann Arbor, Mich.

The names that are in italics indicate the families in which I have seen and studied the crystals, but only in a few cases their chemical composition.

Some of these, as the Onagraceæ and Orchidaceæ, contain large and beautiful crystals. In the vanilla bean, which is a fruit belonging to a species of the latter family, T. F. Meyer, of the university class of '78, has reported and made drawings of the crystals. He states that they are composed of the active principle of the bean and belong to the second class or crystal prisms.

It is often supposed that minute substances have no particular use, and so it may be thought of these minute crystalline bodies; but generally anything that occurs in such abundance and so regularly has some use in the economy of either the animal or vegetable kingdom. On the use of the crystals Prof. Gulliver says: "Although the precise use of crystals in the vegetable economy may be obscure, it is plain that whatever is constant in the plant must be important, and by no means necessarily of little importance because of such obscurity." Taking, for example, the Cactus family, which abounds in large crystals, some specimens of which have been reported to contain so many of these minute inorganic bodies that it was almost impossible to move the plant without breaking it, and when moved it was necessary to pack it in cotton with great care, as if it were the finest jewelry. A case like this is seldom met with, but as the occurrence of crystals is so constant a feature of this family, they must be of some use, which is, as yet, beyond the reach of man's power to perceive, and it would seem ridiculous to say that they have no use as some prominent scientific gentlemen claim.

But such crystals may be of use to man, perhaps in two ways; first, when contained in some medicine.

It is well known that the disease called "rickets" is treated, or at least has been, with sarsaparilla; now the plant itself contains a large number of crystals which are composed of phosphate of lime. Query—why may not this plant, in connection with its tonic effects, also furnish some of the needed phosphate to strengthen the bones?

Second, they may be of use to man when contained in decaying leaves or plants, thus acting as a fertilizer.

Again, crystals are sometimes used by the merchant as a test for the genuineness of a drug. The quality of rhubarb is often

tested by its grittiness, which is due to inorganic crystals, and rhubarb should contain a high per cent. of inorganic matter.

Other uses might be enumerated and given in this list, and perhaps some of them are of more importance than those mentioned, but sufficient has been said to show that they are probably of some practical value to man. It is hoped that this article will induce other investigators to take up this subject and find, if possible, their exact use in the economy of the plant.

The time is probably not far distant when we will know more about microscopical crystals in plants, and for that time we must all wait, each investigator endeavoring to do his best.

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ON THE ORIGIN OF THE LAC.[1]

BY J. M. STILLMAN.

DURING the course of an examination of a product from Arizona, apparently identical with the gum-lac from India, I had occasion to consult various works touching on the origin of this interesting product.

The statements met with were in many cases contradictory, and the most usual statement so directly opposed to what appears to me, from a careful examination of the deposit and of the evidence on the subject, to be the truth, that I cannot refrain from at least suggesting what seems to me to be the true state of affairs. At the same time I wish to state, that as far as the lac insect is concerned, I have not been able to find sufficient data regarding its anatomy and life-history to enable me to touch upon some very interesting points in connection with the subject. Nor am I cer-

[1] This paper was read before the California Academy of Sciences, April 19, 1880.